MVD Review

Oct 29, 2002 BNL

Introduction

A review for the MVD took place at BNL on Oct 29 with committee members Richard Seto (UCR - chair), Achim Franz (BNL), Yuji Goto (RIKEN), and John Haggerty (BNL). The charge from Ed Obrien to the committee was as follows:

> *Review the current status, especially the technical status of the PHENIX MVD to determine whether it is likely that the detector can make a useful contribution to the PHENIX physics program in Run 3. Comment on the utility of the MVD in PHENIX Runs beyond Run 3. Identify any additional resources which should be made available to the MVD group, or actions that need to be taken, to allow the detector to contribute to the near term Physics program of PHENIX.*

John Sullivan (LANL) began by giving an overview and listing the physics goals of the MVD. A discussion took place about the pros and cons of installing the MVD for the pp, dA (Run 3) and AA(Run 4). Hubert VanHecke described the status of the Hardware, John described the status of the electronics, Hubert the installation, and John the manpower and other issues. Slides from the presentation can be found at http://www.phenix.bnl.gov/phenix/WWW/p/draft/seto/mvdreview/mvdreview.ppt and http://p25ext.lanl.gov/phenix/mvd/oct2002_review.html. This document should be available as

http://www.phenix.bnl.gov/phenix/WWW/p/draft/seto/mvdreview/mvdcloseout.doc or pdf.

Physics

The MVD was intended to deliver several important physics measurements for PHENIX as the name Multiplicity-Vertex Detector implies. In the following, several physics points are listed separated for AuAu and pp - dAu running. For all of the physics points, the large pseudo-rapidity (η) and azimuthal (ϕ) coverage of the MVD is beneficial. Especially in the case of pp and dAu running the MVD would provide a much improved centrality selection and vertex position over the currently used BBC and NTC.

Event Vertex:

- **AuAu**: Currently the BBC does a sufficiently job with its resolution of a few mm, but the MVD could improve the resolution to a few 0.1 mm. The larger η coverage improves the selection on peripheral (low multiplicity) events.
- **pp, dAu**: only the MVD can deliver a reliable event-by-event vertex even when measuring only a few particles (5-10). This is critical for di-muon measurements as even a 1-2cm vertex precision would improve the resolution from 200Mev to 120MeV- important for the resolution of the various members of the J/ψ and Υ families.

Overall Multiplicity, dN/deta and charged particle fluctuation measurements:

- **Au Au**: These global measurements require only a limited dataset and could be part of a separate MinBias event sample.

- **pp, dAu**: These global measurements require only a limited dataset and could be part of a separate MinBias event sample.

Event by Event Multiplicity, event selection:

- **Au Au**: centrality is currently measured by the BBC/ZDC via its total pulseheight. The MVD could improve the centrality selection with an event by event multiplicity measurement because of its larger η coverage and segmentation
- **pp, dAu**: The MVD will be essential to define event types.

Reaction Plane:

Currently the BBC and the central arm detectors were used to define the event reaction plane (RP). Having a larger acceptance in η and ϕ around mid-rapidity would result in a better event plane resolution. As these are new measurements and models do not reproduce the current new data reliably, predictions on optimal coverage and segmentations are difficult, but it is generally agreed that the larger coverage of the MVD would be beneficial to the measurement.

- **Au Au**: the coverage would be beneficial.
- **pp, dAu**: the MVD will be essential for the measurement.

Pp and spin physics:

For proton-proton physics, there is no reason not to install the MVD. There is no location conflict with the new NTC this year.

One physics benefit that the MVD gives us is background reduction in the charm physics with single electron measurement. Dalitz electron/positron pairs from pi0 decays and conversion electron/positron pairs at the beam pipe are the major backgrounds in this measurement. Wei Xie performed detailed simulation studies of the MVD response in this measurement. By requiring a pulse height cut and a 10-degree separation cut, 68% of the Dalitz decay electrons and 75% of the beam pipe conversion electrons are rejected by keeping 78% of signal electrons from charm and bottom decays. The asymmetry measurement of the single electrons from charm and bottom decays is one of the feasible measurements to give us the gluon polarization information in the run-3 polarized proton collisions.

Another benefit is possible background reduction in the measurement of high p_T charged hadron spectrum. The measurement with the drift-chamber system cannot reduce backgrounds caused by decays of kaons etc. inside volume and conversion electron/positron at the entrance of the drift chamber. By requiring consistent hit information at the MVD, we can reduce these backgrounds from neutral particles and decays. Detailed studies of this background reduction need to be done.

Conversions electrons caused by the MVD during Au-Au collisions:

The removal of the MVD in Au-Au collisions would reduce the background under the dielectron decay of the light vector mesons and low mass continuum. This is not a problem for pp or dA collisions since the background goes roughly like the square of the multiplicity. The MVD is not as necessary for vertex definition in Au-Au collisions since the Beam-beam counters can give a reasonably good vertex, and the higher track multiplicities would mean that the vertex can be defined using tracks in the spectrometers. The MVD will continue to be important in Au-Au collisions for reaction plane, multiplicity and fluctuation measurements. Two compromises should be considered. The first is to remove the MVD for some period (for example two weeks) during Au-Au data taking giving the entire period to minimum bias triggers. This would be optimum if one could not trigger on the relevant di-electron events. A second possible option would be to remove portions of the MVD as necessary, such as the central, barrel there-by reducing the major source of conversions from the MVD. This should be done in such a way as to minimize the material in the central rapidity region while retaining the structural integrity. Studies should be performed using realistic event characteristics to determine how well the pads alone can measure the reaction plane and multiplicity. Since the Au-Au run will be in run-4 this will give the collaboration some time to understand how the MVD performs, and to optimize the use of the MVD, striking the balance between minimizing the background to the low mass di-electrons and giving good measurements of the reaction plane, multiplicity and fluctuations, and making a realistic plan for possibly changing the configurations of the MVD.

An Exit Strategy

If during commissioning in December, serious technical problems remain, the Physics Working Groups should be ready to provide a rapid assessment of the capability of the MVD in whatever condition it is in, to provide high quality physics measurements. One immediate step should be to estimate the number of channels that have the pedestal problem. If a majority of the channels do not have the problem – then the MVD is probably is in good shape whether the pedestal problem is completely solved or not. However if this is not true then it becomes critical that this problem is solved. If in the unlikely case, it is determined that the MVD will be incapable of providing any physics measurements – then it should be removed early in the run. This can be done with a few hours access. It must be stressed, that the committee believes that this is only a remote possibility.

Hardware

Basically the hardware is in good shape.

The problem of the cooling system happened at brass fittings which touched the aluminum tubes and created holes when disconnecting the fittings. Recovering works for the leaks in cooling system has been half done. It will complete soon. The MVD was disassembled, aluminum tubes were removed, copper tubes were glued, and all brass polyflo fittings are good now. The equipment protection system also has no problem. There were no serious problem in run-2, and its reassemble and test will be done in 12-22 November.

It is found that there is about 5mm sagging/bowing of the MVD barrel. Additional 2mm rohacell sheet at z=0 plane to stiffen the barrel will be put when the MVD is reassembled in a few weeks. Displacement and alignment information can be obtained by investigating the vertex distribution. It takes half a day to give 100-200 micron accuracy in all x, y, and z directions. Condition (temperature, humidity, etc.) at the MVD location is well stable. Just once or twice measurements are much enough in the entire run period.

The hardware and cooling problems are under control.

To modify any configuration of the MVD, it takes half a day to remove it from the PHENIX system. Modification can be done in a week or two. It takes one more day to reinstall it in the system.

Electronics

The MVD group has made impressive strides in identifying and solving some difficult technical problems with the electronics over the past year, with an extremely small group of physicists and no full time engineers. They should be commended for their accomplishments, despite the lack of institutional support for this important part of the PHENIX physics program.

Problems with the electronics fall into two categories. First, there are the basics of PHENIX data acquisition:

- do the beam clock counters all increment together?
- is the detector timed into beam crossing and are resets issued correctly?
- are the correct AMU cells always read out?
- do the glinks remain locked?
- how many of the DCIM's are fully functional and have all known revisions?
- are the power supplies adequately filtered?

Second, there are the problems of the digitization itself:

- are the pedestals narrow and stable?
- is the AMU cell dependence acceptable?
- is the gain of the measured signal reasonably uniform?
- are there rate effects that affect the performance of the digitization?

For both of these categories, there is now convincing evidence that the design goals can be met for a fraction of the detector on the bench. This group, with some help from Chuck Britton and Glenn Young from Oak Ridge, and work done by students and faculty at Yonsei University have proven this in tests done in the lab at 1008 over the summer of 2002. The evidence is quite convincing that a modest number of MCM's can be operated stably and quietly on the bench, even coupled to a silicon detector.

However, it is not yet clear whether that success will translate into successful operation of the entire detector in Run 3, with 120 MCM's, 20 DCIM's, and 15 DCM modules in a single granule. Also, it is not clear what fraction of the approximately 30k channels, which will instrument about 90% of the originally conceived MVD will be sufficiently functional to be able to read out.

Clearly, this question needs to be answered before the MVD becomes part of regular PHENIX data taking. Fortunately, there is an excellent time to characterize the performance of the entire MVD under realistic operating conditions, which is during December 2002, when the MVD will be installed in the PHENIX IR, but not necessarily on the beamline, and there may even be limited occasional access to the detector.

During that time, it is essential to establish stable operation of the entire detector for Run 3. It should be straightforward to determine the adequacy of the operation of the electronics after installation in the PHENIX IR. It will be easy to determine that the glinks remain locked for several hours with the RHIC clock and pedestal data can be taken. Monitoring and calibration software can be developed that can be used for monitoring during the run, and for confirming operation of the detector. The detector should be operated as frequently and for as long a period as possible to measure its performance and to prepare it for regular physics operation. It should become part of regular PHENIX data taking and testing by the DAQ group (which will be completing their own development during December).

There should be stored beam in the RHIC ring during December, which will provide information on noise and perhaps a limited amount of information on the performance of the detector with particle interactions. This is also important information to have before actual physics running begins in January 2003.

If testing and operation of the detector is successful in December, it will be perfectly clear that the MVD should contribute significantly to PHENIX physics in Run 3.

PHENIX management can help the MVD group in a few ways:

- PHENIX engineers can help to measure power supply noise and add additional filtering if it appears to be desirable
- DCIM boards with problems can be examined for construction errors

Installation

All Pad detectors were finished and operational last year and produce a first dN/dη result that was shown to the committee. For this year Hubert van Hecke, John Sullivan, Jan Boissevan and Toshi Shiina will be involved in the installation in November and December. The MVD barrel has 24 cages total (each holding 2 Si wafers): 11 from last year, 13 are new or being upgraded.

Out of the 13 new modules: 3 are completely done and the other 10 are at different stages of assembly, with an estimated time to completion Nov. 7th . These are presently at LANL Starting on Nov. 11th at BNL, there will be a few days of assembly in BNL Physics Dept. Lab. (510 highbay). In parallel a preparation of IR will proceed on Nov. 12th . Installation and testing of the detector in the IR on the lift table below the beam line will begin around Nov. 15th, followed by extensive tests using the PHENIX DAQ. Final installation in data taking position before 'running' period begins will take a few hours. Since the detector moved in and out of position around the beamline rather rapidly, the group may move it into position while access to the MVD is not required to protect the detector.

Several important considerations:

1) Removing the MVD from the IR will would about ½ day. Reinstallation would take slightly longer.
2) A complete disassembly, and reassembly of the MVD takes about 2 weeks.
3) Cutting into the sealed MVD structure to repair a problem would take at least one day for minor problems. Of course, if it were to require disassembly of all or part of the MVD this could take up to 2 weeks.

Manpower and resources

It is clear that the MVD is undermanned with essentially only two physicists from LANL and several students from Yonsei working on the project. Hubert and Toshi Shiina at BNL are doing assembly. Toshi will be supported by LANL until Jan 1. Jan Boissevain, an LANL engineer will be at BNL during part of the month of December for installation (he is supported 10% on the MVD).

It is possible that a Xilinx expert may be needed during the debugging and commissioning phase in December. The “expert” now is a student, Ihnjea Choi from Yonsei. He should be scheduled to come to BNL in December after the MVD is assembled and in the experimental hall. Provisions should be made such that Mijko from ORNL would be readily available by phone to assist him.

Ihnjea Choi will be at BNL for the run. A more senior person (at least at the Post-doc level) will be needed to be at BNL 100% of the time during the run. The two experts John and Hubert will be at BNL about 25%-35% meaning that for at least 35% of the time there will be no MVD expert available aside from a student.

Clearly another person is needed on the MVD project during the run. An additional person would be advantageous for other reasons as well - i.e. offline software, analysis, and calibration. A student from Yonsei, Sangsu Ryu is presently doing all of these things.

If is not possible to provide support for an additional person, a solution might be to join with some of the members of the muon group at LANL to provide such expertise. One of the main reasons for the installation of the MVD is to improve the momentum resolution for muons hence it is in the interest of the muon group to be concerned with the operation of the MVD. People from the muon group assisting in this manner should see themselves as part of the MVD group and become familiar with the MVD and its operation. They should genuinely be able to provide the expertise needed to deal with difficulties that arise during the run.

Long term support needs to be clearly understood for the MVD at least through run 4 after which it may be replaced by other detectors. We received a statement from LANL indicating that there was support for 2 full time physicists + 10% of an engineer through run 3. Run 4 was unclear.

Summary

The MVD group has made good progress in dealing with the technical problems that have plagued them in the past two runs. Hardware problems have all been solved and a majority of electronics problems have been solved. Construction and installation are under control with adequate manpower.

The outstanding problem is the jumping of the pedestals. There are a variety of improvements that have been made to correct this, however, it will not be known whether these will solve the problem until the detector is reassembled and moved into the experimental hall - this will happen in mid November. If the problem remains there is a period of one month in which there is access to the detector to solve this problem. A Xilinx expert may be needed for this in December.

The physics case for the MVD is compelling in pp, dA, with no significant drawbacks. These include - giving a precision vertex for muon measurements, multiplicity measurements over a wide rapidity region, reaction plane measurements, and Dalitz rejection and track confirmation for pp measurements and centrality determination.

The MVD also has an important role in AuAu collisions the MVD however it may be that we wish to remove all or part of the MVD for some part of the running. It will be critical to quantify some of these things through simulations - particularly improvements to the reaction plane and centrality measurements. We note that this will not be until run 4 when we will have more information available from the upcoming run.

Manpower is clearly marginal for support of the MVD. Through intense effort on the part of John and Hubert, it appears as if construction and installation are under control. For the debugging and commissioning the detector in December a variety of experts and technicians should be made available to the group for short periods of time as needed. Additional support is needed for the MVD group during the run in the form of a post-doc, who together with a student from Yonsei can be the local experts when John or Hubert are not at BNL. If this is not possible, some arrangement with the members of the LANL muon group might be used to provide such expertise.

Long term support, i.e. through run 4 needs to be clearly understood by all parties - by PHENIX management, by LANL management, by the DOE and by the members of the MVD group.